NCCA

An Chomhairle Náisiúnta Curaclaim agus Measúnachta
National Council for Curriculum and Assessment

Senior Cycle Science

Report on the Consultation

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1. Introduction

The draft revised Leaving Certificate physics, chemistry and biology syllabuses were approved for consultation by Council in February 2011. The consultation process was envisaged as having a number of different elements:

- an on-line questionnaire, and opportunity for written submissions
- meetings with the subject associations, science teacher networks, third level students, representatives of the STEM industries and third level science departments.

The NCCA's consultation process began in April 2011 and was scheduled to conclude in October. Following requests form the education partners the consultation was extended to December 2nd 2011.

1.1 Online questionnaire and invitation to make written submissions

The online questionnaire was live from April 2011 to December 2011. In total, 511 respondents completed the survey: 203 responded to the biology survey, 107 to the physics survey and 101 to the chemistry survey.

73% of the respondents were teachers, 1% were principals or deputy principals, 10 % were second level students, 5% were parents or guardians while the remaining 11 % comprised third level teachers, academics, scientists, technicians and guidance counsellors. In addition to the online questionnaire, the public were also invited to make written submissions through the website. In total, 29 written submissions were received (listed in appendix 1). While some submissions focused on broad issues, others contained detailed comments and suggestions for changes to the draft syllabuses.

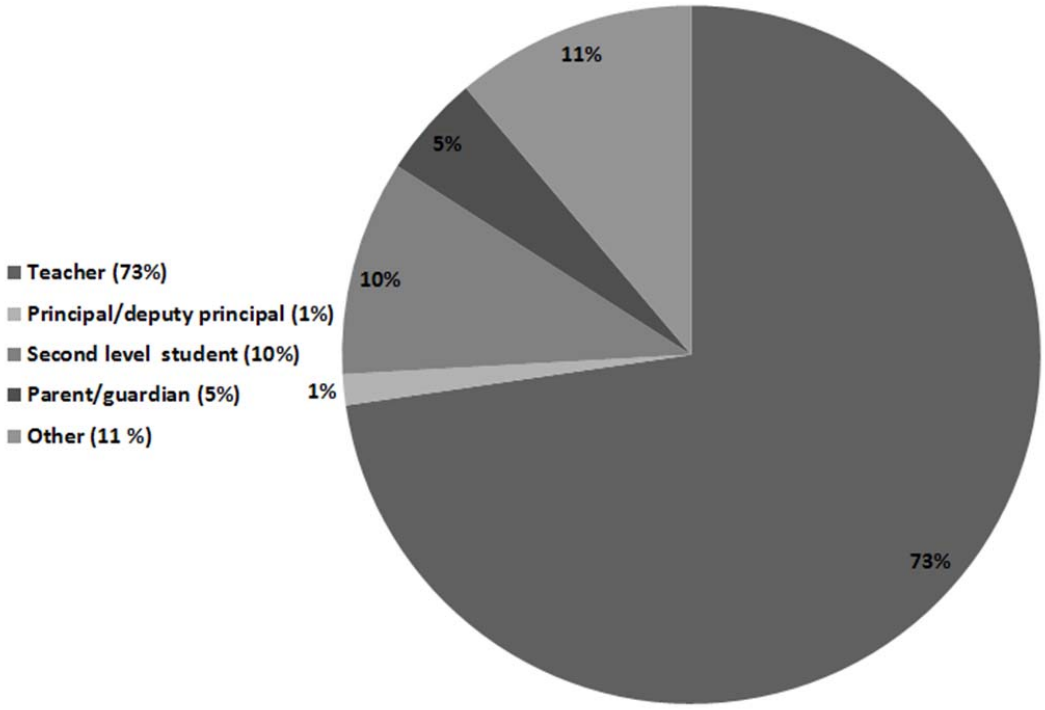

Figure 1. Breakdown of total respondents

1.2 Consultation meetings

Consultation meetings were held with various interest groups. These ranged from meetings with one or two representatives to larger meetings of up to 20 people. Other organisations also held consultation meetings to inform their responses to the consultation. The Irish Science Teachers Association held branch meetings throughout the country. The revised chemistry and physics syllabuses were presented at the Chem Ed conference (180 teachers) and the Frontiers of Physics conference (60 teachers). The teachers at the conferences were encouraged to fill in the online questionnaire following the conferences. Meetings were held with the Institute of Physics, undergraduate students from the Science Education Department (NUI Maynooth), the science network teachers who had been involved in developing the examples for the second component assessment, Pharmachemical Ireland, Engineers Ireland, and Discover Science and Engineering.

1.3 Development of sample teaching, learning and assessment activities

In parallel with the consultation process, the NCCA worked with a number of second and third level teachers to develop sample learning activities and assessment material relevant to the revised syllabuses. The purpose of this was to illustrate the change in focus towards an inquiry-based approach to teaching and learning which promotes an increased emphasis on discussion, debate, critical thinking and problem solving. The material also illustrates the significant change to how learners will engage with and record their practical activities; in particular, the research activity and the open ended investigation.

NCCA also worked with the European Space Organisation through the office of Discover Science and Engineering to develop material relevant to the new topic of space. The material includes sample activities, videos of classroom activities, podcasts describing each of the syllabuses, interviews with teachers and learners, a sample of a web-based laboratory notebook and a glossary of the action verbs of all the learning outcomes in the syllabuses. It also includes assessment material that illustrates ways in which higher order thinking skills, problem solving, interpreting and communicating information can be assessed in contexts that are unseen and unfamiliar, but rely on prior learning of fundamental science concepts.

1.4 Feedback from the consultation

The report outlines the areas of feedback that emerged from the consultation process. These were:

- A broad welcome for the draft syllabuses
- Length of the syllabuses
- Learning outcomes
- Uniformity of syllabus length and style
- Practical activities
- Assessment
- ICT
- The introduction of the draft syllabuses
- Health and safety

The order is not reflective of the weight of comments; the report will look at each of these areas in turn.

2. Feedback from the consultation

2.1 A broad welcome for the draft syllabuses

The draft syllabuses have been broadly welcomed by participants in the consultation.

> *The ISTA supports the revision of each of the syllabi and agrees that the proposed introduction of a second mode of assessment is favourable over the current situation where students are graded solely on a terminal examination. The value of the five key skills upon which each of the revised syllabi are based is acknowledged by ISTA members* (Irish Science Teachers Association).

> *Engineers Ireland welcomes the NCCA's proposed new curriculum in particular its approach on the delivery of the curriculum through enquiry and practical based learning. Its focus on the learning process rather than knowledge acquisition is important. This objective will be further supported by the move to a more outcome based syllabus, which aims to give the learner the important skill of how to "self – learn". This skill and the ability to learn quickly are essential in a modern technological society, where the careers of the future lie in the creative, dynamic and innovative industries of science, technology, engineering and mathematics* (Engineers Ireland).

> *The delivery of a curriculum that promotes inquiry and develops skills as well as knowledge has the potential to provide a different learning experience for senior cycle students. DSE welcomes the proposed use of a broader range of assessment methods for learning by teachers throughout the senior cycle and of learning for certificate examinations* (Discover Science and Engineering).

> *Overall the proposed syllabuses have the potential to enhance the enjoyment of learning science* (Irish Business and Employers Confederation; Pharmachemical Ireland).

> *We would like to congratulate NCCA on these new syllabuses. The overall look and feel of the syllabuses has changed a lot and they are much more learning focused and relevant to the lives of the young people engaging with them. Throughout all three syllabuses there are very rich open learning outcomes. The students are required to think for themselves and to act like real scientists. We welcome the use of terms like 'design', 'apply', 'relate' and 'critically examine'* (Science Education 4th year students NUI Maynooth).

The consultation process highlighted a number of reasons for welcoming the revised syllabus.

- A second component of assessment will encourage practical activities and broaden the basis for assessment.
- Currently there is much criticism of the expectation on learners to learn material off by heart. The revised syllabuses include a broad range of outcomes which will change the focus of learning away from content towards process.
- The revised syllabuses offer learners the opportunity to engage in research and open-ended inquiry.
- The inquiry-based approach will provide continuity with junior cycle.
- The five key skills of critical and creative thinking, communicating, information processing, being personally effective and working with others, identified as central to teaching and learning across the curriculum at senior cycle are integrated throughout the proposed learning activities.
- Updating the syllabuses and changing the assessment arrangements may address the low levels of uptake of the physical sciences.
- The revised syllabuses explicitly include increased use of ICT.
- By presenting science in context, the revised syllabuses will increase learner engagement and enjoyment of science.

The broad consensus from the consultation process is that the revised syllabuses, including the proposed changes in assessment, are a welcome development in Irish science education.

2.2 Length of the syllabuses

There was a widespread feeling that the syllabuses were too long.

> *The changes have resulted in a more modern and contextualised syllabus and the organisation of the learning units is clear and coherent. However, the breadth of material included may well lead to superficial coverage of some topics by students* (Royal Society of Chemistry Ireland, Education Division).

It was acknowledged that the deeper engagement with the syllabus content will take time, as will the higher order practical work. Concern was expressed that if the content is not further reduced it is likely that learning will be superficial.

> *Inquiry based learning is a key element of the new syllabus and this does require more. The syllabus indicates that the students must identify and refine good inquiry questions, plan, perform, analyse, interpret and assess results (*National Centre for Excellence in Mathematics and Science Teaching and Learning).

However it was cautioned that in reducing the content in the syllabus, it is important not to reduce the depth.

> *Engineers Ireland recognises that the spectrum of subject matter may need to be reduced to facilitate more enquiry and practical based learning. However, we would urge that there is no reduction in the depth of subject content across the spectrum in order to facilitate this type of learning* (Engineers Ireland).

The broad consensus from the consultation process is that the syllabuses need to be shortened, while at the same time being careful to maintain depth.

2.3 Learning outcomes

There was a general welcome for the inquiry based approach to teaching and learning.

> *The core skills of investigation and problem solving are important skills required by industry and it is important that these are developed at second level* (Irish Business and Employers Confederation; Pharmachemical Ireland).

While the use of learning outcomes and the move away from highly specified content was generally welcomed, many respondents, teachers in particular, felt that a significant amount of material should accompany the syllabuses in the form of sample teaching, learning and assessment materials. In some submissions, it was evident that the meaning of some of the higher order learning outcomes was not fully understood. This is particularly the case where learners are required to investigate, analyse, evaluate or synthesise.

> *With regard to the experiment to investigate the relationship between i and r for refraction, what or how would we expect a student to stumble upon Snell's law? Or would we expect the student to have encountered it in theory somewhere beforehand?* (physics teacher, individual written submission).

It is worth noting that in the existing syllabuses content is very tightly specified and teachers are directed to one examinable way of teaching particular topics. The focus in the revised syllabuses is more toward higher order thinking and problem solving, and dealing with unseen and unfamiliar contexts by applying prior learning. Examination questions will be less predictable, so it is not surprising that so many of the submissions placed the need for professional development and extensive supporting material for the syllabuses as a top priority.

> *The addition of learning outcomes makes the aims of the syllabus much clearer to all stakeholders. A further addition would be to link each learning outcome to an appropriate teaching and learning activity or assessment. This would help to clarify how it is anticipated each outcome could be achieved. The "describe" and "discuss" type learning outcomes will in most cases be assessed in the exam but it is not so clear how it is*

intended that other learning outcomes can be met and assessed (Royal Society of Chemistry Education Division Ireland).

Several submissions stressed the importance of using contexts from real life and industry to develop science concepts, as this will underline the relevance of science to learners.

Similar to the Project Maths curriculum and in order to provide context and relevance, it will be important that subject content is developed using examples from real life and industry (Engineers Ireland).

In order to increase motivation and interest in science, it is essential that the new curriculum emphasises connections with students' personal experiences, potential careers and their awareness of the latest scientific developments through the media (Irish Business and Employers Confederation; Pharmachemical Ireland).

A number of submissions asked that consideration be given to the insertion of content on potential careers in the STEM industry.

The broad consensus from the consultation process is that samples of teaching, learning and assessment material be developed to illustrate inquiry based teaching and learning. In so far as possible, the fundamental concepts of science as presented in the syllabus should be explored using context based issues in science.

2.4 Uniformity of syllabus length and style

There was criticism about the lack of uniformity across the three syllabuses. The difference in overall length of the syllabuses was mentioned, as was the inconsistency in the specification of content. The chemistry syllabus was particularly criticised for having considerably more learning outcomes, and outcomes that were more atomised and specific than either the biology or physics syllabuses. This has the dual effect of making chemistry appear longer than the other two subjects and more likely to support rote

learning rather than the development of science process skills as specified in the syllabus objectives.

> *With specific reference to chemistry, it is disappointing that the syllabus document is much less refined and longer than the biology or physics syllabuses…….*(Association of Secondary Teachers in Ireland and the Teachers Union of Ireland).

In general, respondents felt that the learning outcomes strike a good balance between practical activities, open-ended investigation and research work. However, the importance of ensuring consistency on the use of inquiry-based learning and emphasis on investigation across all three science subjects was highlighted.

The broad consensus from the consultation process is that the three syllabuses should be uniform, both in terms of length and approach. This consistency should also extend to the practical activities.

2.5 Practical activities

There was considerable support for the range of practical activities in the syllabuses; however, many respondents asked that their number be limited, to allow time for the level of engagement required.

> *The closed and open investigations address a variety of desirable and yet, distinct skills and merit their inclusion in the syllabus. This honours the idea of differentiating the learning experience. In this regard it is considered that each syllabus should include no more than 18 practicals. These 18 practicals should incorporate appropriate emphasis on ICT and include no more than two open ended investigations. Such an approach is critical in terms of teachers being able to give adequate attention to all the prescribed practical work, the related theory and conceptual work as well as retaining sufficient time for other aspects of the syllabus* (Association of Secondary Teachers of Ireland and the Teachers Union of Ireland).

It was further suggested that, given the flexibility of approach allowed in the learning outcomes, the detail of exactly what was to be reported on in the student laboratory notebook should be provided. This detail should include description of the activities that develop fundamental laboratory skills, the open ended investigations and the information research activity. It was also suggested that to avoid confusion, the "research activities" be renamed as *research analysis activities* to emphasise that the experimental data being examined is not new knowledge generated by the learner. Many of the submissions made reference to the research activity and oral presentation as a very welcome inclusion in the syllabus.

> *The use of presentations in the courses is excellent and again a way of relating knowledge and of developing skills that the students will use in life and if they proceed to third level. ……The focus on gathering and analysing data is essential and well emphasised* (Written submission 4th year Science Education students, NUI Maynooth).

However, although there was a general welcome for the increased emphasis on, and inclusion of higher order skills in the practical activities, there was criticism that activities that developed manual dexterity and manipulation skills were being reduced to allow for research based and open ended activities.

> *More lab based practicals that develop manual dexterity and manipulation rather than over emphasis on research skills* (Irish Science Teachers Association).

> *Emphasis of practical work should focus more on lab work that develops manual dexterity, manipulation skills and application of understanding of outcome and less on more open ended research as seems to be the case* (Association of Secondary Teachers in Ireland and the Teachers Union of Ireland).

The broad consensus from the consultation process is that the number of practical activities be limited to allow for the level of engagement required.

There was no consensus regarding the balance between traditional experimental activities and open ended and research based activities

2.6 Assessment

It was evident from the online questionnaire that many teachers felt unsure about how effective the assessment arrangements would be in examining students' learning. Many of the comments indicated that the detail of the assessment arrangements was not outlined clearly enough in the syllabuses, or that they would need to see sample questions before commenting.

> *The assessment arrangements do not really set out clearly enough how the structure of the paper and type of questions will reduce the amount of rote learning and encourage the actual understanding of chemistry* (teacher, online questionnaire).

Of those who responded 46% felt that the overall assessment arrangements as outlined in the syllabus would be effective, 54% did not.

Will the assessment arrangements be effective in examining students' learning?		
	Yes %	No%
Physics	59	41
Biology	39	61
Chemistry	41	59
Total	**46**	**54**

Table 1

The commentary on the online questionnaire suggested that many of the respondents were unclear as to what exactly the second component of assessment would entail and who would be marking it, although this detail was provided on the NCCA website.

> *Further clarification is needed here - will the marks for the write-up be based solely on the experiment being completed or will there be grades for the quality of work done. Also will there be special books that the write-ups have to be done in or will it be up to the teacher to assign their own method of report writing* (teacher, online questionnaire).

> *Yes, but dependant on who is assessing it* (teacher, online questionnaire).

Will the proposed second component of assessment assess the process skills that cannot be adequately assessed in the written paper?		
	Yes %	No %
Physics	74	26
Biology	45	55
Chemistry	58	42
Total	**59**	**41**

Table 2

2.6.1 Written examination

There was general agreement in both the written submissions and the commentary attached to the online questionnaire that the content and style of the terminal written examination will have to change radically if it is to align with the revised syllabuses. Many of the submissions asked that the written examination include questions that require learners to demonstrate higher order thinking skills and problem solving, as well as an ability to interpret and communicate information and deal with unseen and unfamiliar contexts.

> *It is important that the examination is less about recall and more about testing understanding and the ability to apply the scientific method. It would also be nice to see essay style questions on the examination and not merely lower order recall questions* (biology teacher, online questionnaire).

> *A radical overhaul of the terminal exam needs to be undertaken in order to reflect the desired learning outcomes and discourage the practice of rote learning. Without this change it is hard to envisage the desired shift to independent learning with students taking responsibility for their own learning becoming a reality* (Irish Science Teachers Association).

> *……it is recommended that a larger percentage of questions from the higher levels of the taxonomy be asked in the terminal examination.*

> *This will cause a ripple effect down into the styles of teaching and learning that will take place in the classroom, allowing students to become better critical thinkers* (National Centre for Excellence in mathematics and Science Teaching and Learning).

> *…make the written paper out in such a way that will get students to think for themselves. When laying out the paper do it in a way that makes the student think and they must think a question through and solve* (second level student, online questionnaire).

Many of the submissions emphasised the importance of teachers having a very clear understanding from the outset of exactly how each course will be assessed. There were repeated requests for teacher professional development in the area of assessment and for sample assessment material to be produced in parallel with the final drafts of the syllabus documents.

> *Teacher understanding of the assessment process will be a key implementation success factor. Teachers will require CPD and support to enhance their use of assessment as part of the ongoing teaching and learning process so that they can effectively assess student understanding of the process skills and content which underline the desired learning outcomes* (Discover Science and Engineering).

Some concern was also expressed about differentiation at the point of assessment; many of the submissions asked that supporting material address this concern.

The consultation process highlighted the need for teacher professional development in the area of assessment, both summative and formative – how assessment can support teaching and learning. Sample assessment material should be developed that clearly illustrates how differentiation happens at the point of assessment.

2.6.2 Practical examination

A practical examination as part of the second component assessment was broadly welcomed. Understandably, there were some concerns about the exact nature of the

assessment tasks and exactly what they would assess. Many respondents stressed the need for variety and unpredictability amongst the tasks. There were concerns that the validity of the examination would be compromised if there was any possibility of rehearsal of the tasks.

> *The Chief Examiner's report this year highlighted some concerns in regards to the CWB [course work B] process at Junior Cycle, which are mainly related to the prescriptive nature of how teachers are presenting the CWB experiments to students. Students will benefit more, if they are given the opportunity to use inquiry based methods to learn how to investigate scientifically rather than be given an overly structured formula, where they simply learn content* (Discover Science and Engineering).

> *The one positive I can see from the syllabus is the expectation that there will be a practical element to the assessment. I was involved in the piloting of these experiments, and any fears I may have had about the unseen nature of them were allayed* (chemistry teacher, individual submission).

There was a request that the proposed practical examination should be trialled in a controlled environment to establish clear parameters and possibilities e.g. nature of tasks, time/workload involved for student and teacher, access to facilities, planning demands, differentiation of student achievement. As with the written examination, there was a call for supporting material to show the range and types of possible tasks.

Comments relating to the second component assessment on the online questionnaire were mixed. Many welcomed its introduction

> *The proposed second practical assessment will allow students to show what they have learned in Biology by undertaking an experiment that will be marked externally. This process will both strengthen their understanding of Biology but also give students confidence to carry out tasks in the future. This is very welcome* (second level student, online questionnaire).

The proposed second externally marked practical laboratory assessment is a great addition to the proposed new Chemistry syllabus. It will allow students to show what they know in a laboratory environment. It is also a very fair way of examining a student's knowledge by having the practical laboratory assessment corrected externally (chemistry teacher online questionnaire).

If the practical assessment is carefully designed, I think it will really assess the students' ability to work independently, follow guidelines and record/analyse results. This is a good move towards a 'real-life' practical examination. An emphasis should also be placed on analysis and interpretation of results (university biology lecturer, online questionnaire).

The idea of different modes of assessment is promising. Assessment will drive the classroom. I think that more elaboration is needed of how the excellent suggestions re key skills, open investigations, variety in presentation and reports and so on are to be incorporated into assessment (physics teacher, online questionnaire).

Some were not in favour of it

Inevitably the students, even better students will need a disproportionate amount of guidance and therefore [the practical assessment] will not be a valid indicator of the students' skills. I think the written paper along with the prescribed activities can be structured to demonstrate the students' abilities in this regard (chemistry teacher, online questionnaire).

Too much 'guidance' from teachers will be required creating 'dependant' learning (guidance counsellor, online questionnaire).

> *No. Many of the process skills are key skills such as communication, working with others, learning how to learn, being personally effective, presenting [are] best assessed by the teacher or a portfolio assessment (*biology teacher, online questionnaire).

> *No - proposed method relying on writing answers in a booklet. No manipulative skills assessed (*biology teacher, online questionnaire).

Some submissions articulated concerns about the range and nature of tasks that could be performed by learners in the allocated 90 minute period

> *It is not clear what type or range of experiments can be done with a few droppers and chemicals. Can they make accurate and precise measurements? Large areas of the prescribed practical work cannot be assessed if they are not expected to use burettes, pipettes, Quickfit apparatus, Bunsen burners, balances filtration, etc.* (National Centre for Excellence in Mathematics and Science Teaching and Learning).

Most submissions commented on the resource implications of the second component assessment, both financial and logistical. These will be dealt with in section 2.8.

Although the broad consensus of the consultation process was that a second, practically based component of assessment was a welcome addition to Leaving Certificate science, opinion was divided as to whether the proposed model would assess the process skills that cannot be adequately assessed in the written paper.

The broad consensus of the consultation process was that the practical examination should be unpredictable and that the tasks should be varied and unseen. It should not be possible to rehearse for the practical examination. Sample material should be available in the supporting documentation.

2.6.3 Laboratory notebook

It is proposed that the laboratory notebook will form part of the second component assessment and will be a personal record of the learner's practical achievements; the presentation, the open-ended investigations and the closed experiments. It is envisaged that the record will be stored electronically, possibly web-based, and that learners could report on their activities using a variety of media. Many respondents commented that the draft syllabuses did not describe the contents of the laboratory notebook in enough detail. Because of this, some respondents assumed that the notebook would comprise a set of reports of mandatory experiments, and as such, should not form part of the terminal examination. There was a general welcome for the research investigation and the open ended investigation; these were seen as worthy of contributing to the final mark, indeed, many contributors thought that 5% did not reward this important aspect of student learning adequately.

> *Research activities are an excellent idea and are necessary for the presentations. The presentations should be done in groups, and these should be included in the student portfolio and contribute to their 5%* (Institute of Physics, Ireland).

One person suggested that the laboratory notebook should be renamed student portfolio and that the list of what it was to contain should be described in detail in the assessment section of the syllabus. Also, that it should be made clear that the portfolio can exist in a variety of multimedia formats, and stored electronically.

Examples of how the notebook can be stored and presented should be included with the support material that accompanies the syllabus.

2.6.4 Weighting of the second component assessment

Although a small number of submissions identified the 20% weighting for the second assessment component as appropriate, most of the submissions that addressed this question suggested that, in the context of a subject that placed such an emphasis on

engagement in practical activities, the 20% weighting for the second component was too low

> *Is a total of 20% for practical assessment sufficient; it is 30% currently [current physics examination] (section A)? If the presentation is included with experiment reports, could 10% be given instead of 5%? [for the laboratory note-book] (*science network teacher focus group).
>
> *The weighting currently proposed for the second component of assessment (20%) is much too low. It is contradictory and unfair to increase the focus on practical activity during the learning cycle and then attribute a low status and low value to such work by allocating a low weighting to it in the state examinations. The proportion of marks assigned to the second component of assessment should reflect the importance of practical activity in the teaching and learning environment and the energy it will demand…..it is advised that the percentage of marks to be allocated to the second component be increased to 35% - 10% for the laboratory notebook, and 25% for the practical examination* (Association of Secondary Teachers in Ireland and Teachers Union of Ireland).

There is broad consensus from the consultation process that the percentage of marks allocated to the second component assessment be increased.

2.7 ICT

There was a general welcome for the explicit reference to the use of ICT in the learning outcomes.

> *The integration of ICT into the curricula is most welcome. Due to the proliferation of ICT in the workplace, it is critical that students are comfortable with the various forms of technology that they will potentially use in their careers* (Engineers Ireland).

> *The use of dataloggers and ICT is welcomed. Results and reports from these tools have to be accepted in write-ups* (Institute of Physics).

It was noted that the rollout of high speed broadband to all second level schools will enable the use of Web 2.0 and cloud based tools to bring the use of virtual investigations, simulations, real time data, learner/expert collaboration and innovative presentation of student work into classrooms. Reference was made to the considerable scope for the use of ICT and the internet to carry out the practical element, and to record and present findings. As mentioned in section 2.6.3, a practical use of IT will be the online laboratory notebook. There were requests for further opportunities to use ICT, for example in video analysis, to be highlighted as much as possible within the syllabus and in the supporting material.

Although the increased emphasis on the use of ICT was welcomed, some cautionary notes were expressed. Some respondents argued that the way the learning outcomes were phrased suggested that use of ICT be limited to simplistic activities such as collecting and recording data. The use of ICT to develop student concepts and deepen understanding is not explicit. Much of the commentary about ICT focussed on datalogging and collection of specific sets of data rather than ICT as a facilitator and promoter of process skills and conceptual development.

> *Sensors often do not collect reliable results. CO_2 and O_2 sensors are very expensive and not reliable for the practical specified. If this [learning outcome] is to remain, a suitable sensor for this practical needs to be demonstrated* (Irish Science Teachers Association).

There were requests for more focus on the embedded use of ICT in teaching and learning rather than on use of ICT equipment for collecting and recording data.

> *Simple harmonic motion has been removed when it is simple to introduce through ICT. It is very important in the introduction to waves. I think this reflects the general lack of impact of ICT on the learning outcomes proposed. ICT is seen as a decoration not something which changes how physics teaching and learning should be done* (teacher, online questionnaire).

> *Careful review of what we want students to be able to do in the changed environment afforded by sensors and other ICT tools is recommended at this time. The current proposals add sensors and simulations in a minimal way. The changes may have little effect on practice* (individual submission, Physics teacher).

> *We feel that basic things, done well, reap better rewards than the use of technology for its own sake. A good example is the use of software to construct a range of molecules using VSEPR. This removes the student from the process by one step. The use of relatively inexpensive simple molecular models achieves the same aim, but involves the student directly in the process* (chemistry department NUI Maynooth).

The consultation process welcomed the explicit inclusion of ICT in the learning outcomes, but suggested that the use of ICT should not be restricted to simple collection and presentation of data. The learning outcomes should be reframed in ways that encourage use of ICT to enhance the learning experience and support problem solving and higher order thinking.

2.8 Introducing the revised syllabuses to schools

Most of the submissions made reference to the resources that will be required for successful introduction of the revised syllabuses.

> *The single greatest obstacle to reform is likely to be resources in a severely constrained environment. However while this reality should be acknowledged, it should not be permitted to undermine a project that has critical implications for Ireland's future economic development. All stakeholders should approach the challenge with a positive attitude and a focus on solutions* (Irish Business and Employers Confederation; Pharmachemical Ireland).

Many of the submissions referred to the resources that will be required to upgrade laboratories, particularly with IT facilities. It was stressed that the revised syllabuses place practical activity very much at the centre of learning and that laboratories must have sufficient equipment to allow for the theory and associated practical activities to be carried out at the same time by everyone in the class.

> *Regarding the issue of laboratory resources, it was reported [at branch meetings] that there were huge variations from school to school in the availability of class sets of working, up-to-date datalogging equipment. Furthermore, specific equipment required for investigations introduced to the revised syllabi are not currently present in schools. These will need to be made available. Members also indicated the difficulty of gaining access to laboratories in schools* (Irish Science Teachers Association).

There were frequent references throughout the submissions to the significant resources that would be required for the practical examination.

> *The practical assessment is also an initiative worth introducing but will need careful thought as regards training, resourcing and implementation. The pilot trials conducted are very promising but roll out on a national level is a big undertaking* (Royal Society of Chemistry Ireland: Education Division).

Respondents placed continuing professional development as one of the most important deliverables in the introduction of the new syllabuses. The areas that were most often mentioned were subject content knowledge, inquiry based learning, use of technology and assessment.

> *Appropriate and timely professional development adequately resourced and supported will be critical to effective implementation of the new syllabuses and assessment approach. Of particular concern in this regard is the inclusion of new topics which many teachers have not had an opportunity to study or obtain in-service on and the strengthened emphasis on research activity* (Teachers' Union of Ireland and Association of Secondary School Teachers).

It was stressed that high quality teacher education, both pre-service and in-service, will be very important. Many science teachers have not had the opportunity to utilise inquiry-based approaches in everyday teaching or to support students in adopting them as a learning strategy and will require significant support. Teachers will need guidance on achieving a balance between content knowledge and skills and on how to use assessment methodologies to check that key skills are developed as the learning outcomes are achieved.

It was suggested that the use of e-learning and online communities of practice could deliver effective and timely support to teachers in a cost effective way.

The broad consensus of the consultation process is that an appropriate range of resources and supports must be in place to ensure successful introduction of the revised syllabuses. This support should include high quality pre-service and in-service teacher education.

2.9 Health and safety

The submission from the Health and Safety Authority outlined the opportunities that the revision of the syllabuses provides to develop skills of health and safety management in learners.

> *Many students will pursue careers or undertake work placements in the science field and will have to make decisions around health and safety. Students should understand key safety and health*

terminology and the value of managing risk both in personal and economical terms (Health and Safety Authority).

The Authority proposed learning outcomes for including these principles along with proposals for incorporating useful health and safety resources specific to each of the three subjects. They also welcomed the recording of activities in the laboratory notebook as part of the second component assessment, making the point that identifying the hazards they are working with and recording them in their notebooks will improve learners understanding of health and safety and develop skills in managing risk.

The consultation process suggested that greater prominence be given to skills of personal health and safety management.

3. Feedback on particular subjects

3.1 Chemistry

The syllabus layout was well received. 95 % of respondents to the online questionnaire agreed that the layout of the syllabus was clear and that the language was easy to understand. 93% agreed that the learning outcomes described clearly what students should be able to do and 90% agreed that the learning outcomes will be useful in planning and designing the courses. However, 52% agreed that there were areas of the syllabus that should be removed, reduced or revised. The commentary in the questionnaire and the submissions suggested that a significant amount of material should be deleted to make way for new material and for deeper engagement with the content.

> *A cautious welcome was extended to the new material included but any enthusiasm was overshadowed by the issue in point 1 above [length of the syllabus]. …. "green chemistry" in industry should be included. All submissions mentioned that insufficient old material had been deleted from the syllabus to make room for new material and to allow for new emphasis on practical work and the second mode of assessment* (Irish Science Teachers Association).

As well as criticisms about the length of the syllabus, there were also concerns expressed that the revised syllabus did not represent significant change.

> *The use of learning outcomes is only a token repackaging of the syllabus. One would have hoped for a more radical approach. (*National Centre for Excellence in Mathematics and Science Teaching and Learning).

> *The new syllabus represents a relatively small change from the previous one. We feel that a more radical overhaul of the syllabus will be required to meet the objective of creating "resourceful, engaged, confident, active learners", a more problem-based approach is a minimum requirement. A less structured programme which allows teachers some flexibility in what*

> *they teach may also be appropriate. We would also like to see a reduction in the 'rules of thumb'. While these make it easier for students to answer a question, they discourage the student from understanding what they are doing and why they are doing it* (Department of Chemistry, NUI Maynooth).

> *We have noticed that in the chemistry draft syllabus, there does not seem to be a great move away from the "learn by rote" type syllabus of the past. It appears to be very similar to the current syllabus. We feel that the draft chemistry syllabus is still quite exam driven. There are a lot of lower order skills required. We feel that a lot of teachers will be happy with the chemistry syllabus, as long as the exams stay the same as they are currently. If the exam is to change, then this syllabus may not adequately prepare students for a new style of exam* (science network teacher, focus group).

While the syllabus was criticised for being too close to current practice by some, it was welcomed as being of the same high standard by others

> *In general the new syllabus was welcomed as a document that maintained the high standard of chemistry in the present syllabus…..The fact that the fundamentals of chemistry are maintained within the syllabus whilst at the same time the syllabus is updated to take account of modern developments in chemistry is welcomed* (National University of Ireland Chemistry Departments).

Although the questionnaire data suggests that the learning outcomes clearly described what learners should be able to do, there was criticism in the submissions of over-specification and the emphasis on learning specific chemicals and reactions and chemical names rather than focusing on the fundamental concepts and language of chemistry

> *Science graduates of organic chemistry are the backbone of the pharmachemical industry. Therefore, we would prefer to see more emphasis on learning the fundamental principles. Students should not be encouraged to just memorise the chemical names; instead, emphasis*

> *should be placed on the basic understanding of the principle rules of organic chemistry.* (Irish Business and Employers Confederation; Pharmachemical Ireland)

The introduction of current developments in chemistry was welcomed, in particular Nano chemistry. However, there was concern that applications of chemistry to everyday life were lacking.

> *Is there room to show more about the impact of chemistry on life and medicine? Or the role of chemistry in solving problems, or green chemistry? How chemistry has been at the basis of major developments in biology (e.g. organic chemistry behind structure, synthesis of peptides, nucleic acids as tools for biology and medicine)* (National University of Ireland Chemistry Departments).

There was criticism that some of the material relating to science and technology in society was for Higher level students only. In the online questionnaire, 30% of respondents felt that some of the learning outcomes were inappropriately assigned as Higher level or Ordinary level. In one of the submissions it was argued that some of the applications of chemistry currently restricted to Higher level students would be interesting and appropriate for all students. For example, the learning outcome *Students should be able to discuss the challenges facing society resulting from increased requirements for water and better sewage systems* was thought equally suitable for Ordinary level and Higher level students, and would provide an interesting topic for the research project and oral presentation for both Ordinary and Higher level.

Although there was criticism in the submissions that the chemistry syllabus did not have the same opportunities as the other syllabuses for research activities or open-ended activities, 55% of respondents in the online questionnaire strongly agreed or agreed that the revised syllabus *will develop in learners skills in scientific inquiry, including the ability to analyse and interpret quantitative and qualitative data,* with a further 25% agreeing somewhat with this statement.

The broad consensus from the consultation process is that the amount of content knowledge addressed in the chemistry syllabus should be reduced. The content should focus more on fundamental principles rather than specific examples of chemicals and chemical reactions.

The broad consensus from the consultation process is that the chemistry learning outcomes be reframed to emphasise a more inquiry based approach and include applications of science and technology in society at both Higher and Ordinary level.

3.2 Physics

Of the respondents to the online questionnaire, 78% agreed that the layout of the syllabus is clear and also agreed that the sections and learning outcomes were clear and unambiguous, while 92% agreed that the learning outcomes described clearly what students should be able to do and 87 % agreed that the learning outcomes will be useful in planning and designing the courses. Only 60% felt that the learning outcomes will provide support for teaching in and learning in mixed ability settings.

There was a general welcome for the new content in the draft syllabus, both in the questionnaire and in the submissions

> *Delighted to see the introduction of the big bang theory, as it is highly relevant. A very well thought out syllabus that will be very appealing to students* (physics teacher, online questionnaire).

> *I found it quite applied, and the divisions were interesting. I would have liked to see more of the mystery! Such topics as black holes, and dark matter or dark energy give students a sense that they know things that ninety per cent of the world doesn't know, and this can be a powerful motivational incentive to learn (physics teacher, online questionnaire).*

However, 52% of those who responded to the online questionnaire felt that there were areas of the draft physics syllabus that should be revised, reduced or removed. This was supported both in the commentary on the questionnaire and in the submissions. While there were many suggestions about material that should be included or brought back into the syllabus, there was no agreement about what should be removed to make room for it. For example, many people welcomed the introduction of seismology, and saw it as a very good way of providing a context for theoretical material that learners will enjoy and be fascinated by.

> *,,,seismology, welcome development* (Institute of Physics focus group).

However, others, Including the Irish Science Teachers Association called for the removal of this new area of learning, as they did not see the study of earthquakes as being relevant to Irish students.

The reduction in the modern physics section was criticised in both the online questionnaire and in the submissions.

> *I do not see much about particle physics in the syllabus and wonder what section this comes under, as it would be a shame for them to not learn about the quarks etc.* (teacher, online physics questionnaire).

The request to include particle physics and fundamental forces was a recurrent theme in the submissions.

> *The areas I think are missing are particle physics (something about quarks etc.) and quantum physics. With exciting results coming from CERN in the next few years, I think that this is a pity. …….I think everyone should know that our intuition is based on "human-scale" phenomena and is in fact completely wrong when you go to small (quantum) or large (relativistic) scales. The universe is a lot more weird than most people can imagine. The fact that we can't really imagine it shows why we need maths. I also think it is important that students know there are still debates as to how to interpret theories.*

> *We know how to use them and get answers from them, but we don't know yet what they mean* (physics lecturer, individual submission,).

> *…this revised syllabus has the opportunity to highlight the importance of particle acceleration in future scientific investigations, significant coverage should be given to the cyclotron since its opportunity can be explained using concepts from kinematics, force and magnetics. It is also important to highlight the general operation of the LHC [Large Hadron Collider] since it will dominate particle physics and science in the media over the coming years* (National Centre for Excellence in Mathematics and Science Teaching and Learning).

> *....because of its intrinsic importance to physics, because it underpins and explains the phenomenology of the last 100 years and because students seem to enjoy and are fascinated by it, I strongly urge you to include this subject [particle physics] in the revised syllabus* (School of Physics, University College Dublin).

There was a general welcome for the structure of the syllabus. However, many did not like the names of the units, and noted that they were inconsistent with the style of the names of the units in the biology and chemistry syllabuses.

> *I think the names are a bit 'trendy' but I like the grouping of relevant topics together; it always seemed strange for optics and waves to be totally separate* (physics teacher, online questionnaire).

> *Some of the titles of the units are ridiculous e.g. "Surfing the Physics Wave", "Physics Matters", "At Home with Physics"* (Irish Science Teachers Association).

Although only 59% of respondents to the online questionnaire thought that the assessment arrangements in the syllabus will be effective in examining student's learning, most of the comments were very positive.

> *The combination of the written examination along with the proposed new second assessment where the student will carry out a laboratory experiment, with the marking being carried out externally is truly inspired. In the written examination make sure the questions are put in a way that will get the students to think for themselves* (second level student, online questionnaire).

> *…yes, and in my experience some ordinary level students are very proficient in the lab, sometimes even more so than the super academic. Also a major element of physics in third level and beyond is practical and the skills they will be tested on will stand to them* (teacher, online physics questionnaire).

Only one comment out of 27 on the online physics questionnaire was completely negative about the second component assessment, but some were cautious.

> *It is possible, but with only 15%, and some of that for following instructions and possibly also traditional graphing skills there may not be enough to effect change across the syllabus* (teacher, online questionnaire).

The general welcome for the second assessment component in physics was strongly reflected in the submissions

> *I very much welcome the increased emphasis in the draft [physics] syllabus on the developments of students' key skills and problem solving capabilities, as well as on practical activities and assessment of the same* (physics lecturer, individual submission).

> *It is refreshing to see that assessment of the students' practical abilities forms a component of the assessment on the proposed [physics] syllabus* (National Centre for Excellence in Mathematics and Science Teaching and Learning).

The broad consensus from the consultation process is that the updating of the physics syllabus content to include new material, particularly space science is very welcome. Greater prominence should be given to modern physics, particularly particle physics.

The consultation process suggests that the units in the physics syllabus be renamed so as to make the naming convention consistent with chemistry and biology, and restructured so that the fundamentals of physics are stressed, making the Higher level outcomes more intuitive for learners.

There was broad agreement in the consultation process that the proposed second component of assessment could assess the physics process skills that cannot adequately be assessed in the written paper.

3.3 Biology

Of the respondents to the online questionnaire, 81% agreed that the layout of the syllabus was clear. 66% agreed that the sections and learning outcomes were clear and unambiguous while 70% agreed that the learning outcomes described clearly what students should be able to do and 87% agreed that the learning outcomes will be useful in planning and designing the courses. 68% felt that the learning outcomes will provide support for teaching and learning in mixed ability settings.

On the content of the draft syllabus, opinion varied widely, both in the online questionnaire and in the submissions. In common with the physics and chemistry syllabuses, there was agreement that the syllabus should be reduced in length to allow for deeper engagement with topics. In the online questionnaire, 68% of respondents (80% of whom were teachers) felt that there were areas of the syllabus that should be revised, removed or deleted. The extended comments on the online questionnaire relating to the content of the draft biology syllabus varied widely.

I'm delighted to see the course developing along the IB "style" where students have to take responsibility for their own learning. Good to see data interpretation also on the syllabus and I like the updated sections in the various modules particularly Genetics (teacher, online questionnaire).

I feel the new unit structures are a more natural order to teach the senior biology course, the increased emphasis on contemporary issues and developments in biology will be invaluable for students moving to third level science. Also the introduction of a level of debate will help prepare students on a personal development basis (teacher, online questionnaire).

It is nice to see the terms "bioinformatics" and "GM organisms" mentioned, which is admirable, and there is a great focus on gathering and analysing data. I feel there should be more detail on areas like gene therapy, stem cells and Nano science (teacher, online questionnaire).

The level of difficulty in this draft syllabus has increased dramatically. The addition of the genome material in addition to the extensive DNA material already on the syllabus will make the course very difficult for students. All of it is very abstract. No concrete areas for students (teacher, online questionnaire).

The syllabus is barely recognisable. Where's the plant biology for the farmers and horticulturists of the future. Where's the microbiology, the nervous system, the skeleton ???? Biology is a practical subject that needs to be done, some ICT is useful. This syllabus is not rooted in reality - it pre-supposes all students are potential PhD candidates and that they all go to well-resourced fee paying schools in Dublin 4 (teacher, online questionnaire).

This lack of consensus was also reflected in the submissions. Some submissions expressed concern that the draft syllabus had too much modern biology at the expense of the classical zoology and botany topics; others welcomed the fact that some of the

traditional topics that were generally learned off by heart by learners had made way for modern, applied biology topics.

> *General dissatisfaction about the reduction of human biology topics particularly the exclusion of the musculoskeletal system and the sensory system* (Irish Science Teachers Association).

Others felt that the draft syllabus was still very traditional, with modern biology not sufficiently represented.

> *There is an overemphasis on traditional aspects of biology, namely animal biology and botany* (Microbiology Department, University College Cork).

There was concern that some aspects of the syllabus still reflected an outmoded view of biology

> *Unit 3 "Organisms and their ecology" presents a superseded view of biological classification and, if unamended, will disadvantage Irish students by equipping them with forty year old scientific dogma that has been largely invalidated by advances in molecular phylogeny since the 1970s (College of Science, Engineering and Food Science, UCC, endorsed by Departments of Microbiology NUI Galway, NUI Maynooth).*

There was also concern that insufficient emphasis was given to modern developments in microbiology, given that these will underpin our approach to emerging infectious disease and antibiotic resistance, new biotechnologies, global warming and energy security.

> *I would express concern at the large amount of microbiology removed from the syllabus (yeast, fungi, moulds) as their economic importance is vast in relation to medicine and the food industry* (biology lecturer, individual submission).

There was little agreement about the practical activities. Some argued that too many traditional practical activities have been removed to make way for research activities and open-ended investigation

> *The huge changes in the experiments would also be worrying. The enzyme experiments are very beneficial to students and it shows them*

exactly what they are learning into practice. To be honest I think the content of the present syllabus is good, why is there a need to change it? (biology teacher, online questionnaire).

….. more lab based practicals which develop manual dexterity and manipulation skills rather than over emphasis on research skills (Irish Science Teachers Association).

Get the IT labs out; it's biology they should be dealing with, live things not computers. The data sensors are no excuse for direct measurements (biology teacher, online questionnaire).

Others welcomed the inclusion of the information research activity and oral presentation

The transferrable skills of communication of such biology concepts in society - reasoned debate and argumentation, as part of science presentation - seem to have at last emerged in the biology syllabus but these types of skills need to be more visible across the science curricula. They are crucial for a new type of 21st century scientists (and citizens) where issues of risk and scientific knowledge are contested in the public sphere (science communications lecturer, Dublin City University).

I think it is excellent students are being rewarded for practical aspect! It will encourage teachers to teach more inquiry based lessons and stop spoon feeding students which will hopefully have a knock on effect at third level! (teacher, online questionnaire).

However there was a concern that if the research activity and oral presentation did not figure in some way in assessment, that it might be ignored by teachers and not carried out by learners.

The research activity and presentation involves the perhaps previously neglected key skill of scientific communication. However, will teachers give this activity the time we feel it should merit? It is the most likely

activity to be axed if it is not examined in some way (science network teacher focus group).

There was some concern that the issues of science and technology in society have not been represented adequately in the revised biology syllabus. There were suggestions to have a social implication/public issue sub-unit contained within each unit, to collect these learning outcomes from across the syllabus and present them as a stand-alone unit. This would engage learners in wider societal issues, and science and technology's relationships with them.

It is a major omission and very regrettable that there is not a complete unit with a title of "biology and society" or something similar. Aspects of this concept are scattered through the different units and this merited a unit of its own to give sufficient emphasis to the most exciting and interesting aspects of modern biology (College of Science, Engineering and Food Science, UCC, endorsed by Departments of Microbiology NUI Galway, NUI Maynooth).

It is useful to see that ethics is mentioned explicitly and this is well connected within the syllabus. However, the basis of decision-making and any basic background in ethics is not mentioned. This is a great area to get involvement of students in key issues, get their ideas, encourage debate and it provides a natural forum for critical analyses, project development, group work etc. These are mentioned as key to our education and learning and future activities as active and responsible citizens. Therefore, the vision, objectives, syllabus, assessment approaches and associated marking should reflect this (Life Sciences Committee, Royal Irish Academy**)**

There were some suggestions about restructuring the content within the units, and also about inaccuracy in unit 5.

Unit 5 is named "Systems biology". This term as used is incorrect and has a very specific meaning in modern biology. Systems biology relies heavily on computation science and mathematical modelling and not just

on biological "systems" as is covered in this unit. The term "systems biology" should not be (mis)used (College of Science, Engineering and Food Science, UCC, endorsed by Departments of Microbiology NUI Galway, NUI Maynooth).

Bioinformatics needs to be put in some context and linked to a practical application as given later under genetics. In fact, linking of sections would be valuable to teachers, students and to understanding how biology is integrated (Life Sciences Committee, Royal Irish Academy).

The genetics element of the draft syllabus is very acceptable and even admirable in content, but the lack of content of an evolutionary biology aspect of the syllabus does not do justice to the inclusion of the genetic content (biology teacher, online questionnaire).

Many of the respondents suggested particular areas for inclusion or deletion.

The broad consensus from the consultation process is that the amount of content knowledge addressed in the syllabus should be reduced.

There was no consensus from the consultation process as to the appropriate balance between traditional biology and modern biology or between research/open-ended activities and more traditional recipe type experiments that develop manual dexterity and psychomotor skills.

The consultation process suggested that the learning outcomes in the draft biology syllabus be reframed to ensure that they are in keeping with current scientific orthodoxy.

4. Progressing the findings of the consultation

The consultation process has raised a number of issues with respect to the draft syllabuses. This section of the report will address some ways in which progress can be made on the issues raised in the consultation.

4.1 Length of the syllabuses

The consultation process does seem to suggest that there is too much in each of the syllabuses. However, notwithstanding the concern from respondents about the length of the syllabuses, they almost always suggested even more topics that they felt should be added. Traditionally there has always been a broad range of content areas studied in Leaving Certificate chemistry, biology and physics. It is difficult for many teachers to imagine a syllabus without any of the 'core' areas of their subject. Reducing the content of the syllabuses, while at the same time bringing a new focus to key issues will require, in some cases, significant rethinking the syllabus organisation. It will also mean removing some aspects of the syllabuses that met with approval during the consultation process, and that have always been present in previous syllabuses.

4.2 Learning outcomes

The five identified key skills are embedded in the learning outcomes. In some cases, applications of science and technology in society will provide the context for the learning outcomes. Many teachers who responded to the consultation asked for a description beside each learning outcome detailing exactly what content learners must know to satisfy the learning outcome, much the same as in the current syllabuses. As the revised syllabuses focus on what the learner should be able to do rather than on what they should know, illustration of learning outcomes is best done by example. Samples of teaching and learning activities, including multimedia support, will be developed. The samples will not be definitive; they will show possible ways in which a selection of learning outcomes might be achieved. A glossary of learning outcome action verbs will be included in the supporting documentation for the science syllabuses. Support materials for both teachers and learners will play an important role in effectively communicating the syllabus intentions. Samples of a range of information research

projects that illustrate how learners can apply science concepts from the syllabus to the most recent developments in science will be useful for teachers and learners. The research projects will also provide opportunities for learners to research careers in STEM that they have a particular interest in, as well as making them aware through their research of the many and varied career possibilities in STEM.

4.3 Uniformity of syllabus length and style

The broad consensus from the consultation process is that more work needs to be done on making the three syllabuses uniform, both in terms of length and approach. This consistency should also extend to the practical activities. This should focus on three main areas:

1 The level of content specificity – the biology and physics syllabuses differ from the chemistry syllabus in the degree of specificity of content in the learning outcomes. The general consensus is that the learning outcomes in the chemistry syllabus should be re-worded to allow for a degree of flexibility.

2 The nature and number of practical activities – the consensus from the consultation is that the practical activities should be limited and carefully chosen. It was acknowledged that many of the practical activities in the revised syllabuses require a much deeper level of learner engagement than those in the current ones. The range and level of the practical activities should be consistent across the three syllabuses. The number of open-ended investigations, closed experiments and information research activities should be clearly stated

3 The number of learning outcomes – each of the syllabuses should be equal in length.

4.4 Practical activities

The practical activities in the revised syllabuses include a far broader range of learner experience than do the mandatory activities listed in the current ones. It is evident from the consultation process that the range of activities should be described in more detail, demonstrating the alignment of the activities with the syllabus objectives. The description should include illustrations of how learners develop psychomotor skills and learn basic

laboratory techniques as they carry out all their practical, laboratory activities, including the open ended activities. The research activity and oral presentation is a desirable addition to the range of practical activities, but will require a significant amount of time. Some of the prescriptive activities that replicate others may have to be removed to allow time for extended inquiry based activities.

It was also evident from the consultation process that the reporting of the practical activities as an intrinsically important aspect of how learners develop skills in scientific communication was not adequately communicated. A section should be included in the syllabuses describing how the practical activities will be presented.

4.5 Assessment

There was consensus that assessment will have to change from its present format. However, it was evident that, in some cases, the participants in the consultation process did not have a clear understanding of exactly how each subject will be assessed. Questions in the written examination that focus on higher order thinking skills and problem solving in unseen situations will address some of the concerns about the assessment of skills raised in the consultation. Sample assessment material will illustrate how the subjects will be assessed, as well as illustrating how differentiation will happen at the point of assessment.

Some of the respondents were not clear about how the second component assessment would assess practical skills. The ways in which the second component assesses outcomes that cannot be assessed by the written paper should be clearly outlined. As stated in section 4.4, a clearer description of the learners' record of practical activities should be included in the syllabuses. Most respondents who expressed an opinion on the assessment weighting said that the percentage of marks awarded for the second component of assessment be increased from the proposed 20%.

4.6 ICT

Following the feedback from the consultation process it may be necessary to enhance the capacity of the syllabuses to deliver on the objectives in relation to ICT. This could be

achieved by putting more emphasis on using ICT for a wide range of inquiry-based activities including simulation, analysis and evaluation, rather than for a limited number of data collecting activities. It could also be achieved through making explicit the scientific process skills which learners should develop through appropriate use of ICT.

4.7 Introducing the revised syllabuses to schools

The findings of the consultation will feed into planning for introducing the new syllabuses into schools and recommendations on the resources needed for that.

4.8 Issues with individual subjects

Many submissions, particularly those from the Irish Science Teachers Association and the teacher unions were detailed in terms of the content that they felt should be included or left out of each of the syllabuses. Also, there were suggestions from the consultation process regarding some restructuring of the syllabus units. The course committees will consider these more detailed recommendations and make changes as appropriate. To support them in decisions of this kind, they will have access to information on international practice, and specific input from third-level expertise.

5. Conclusion

The consultation responses signal a broad welcome for the focus of the review of the science syllabuses. There is a general acceptance that throughout the courses involved learners should engage in inquiry with the attendant change in focus of the practical activities as currently undertaken. As learners develop knowledge and understanding of fundamental science concepts and ideas, they will develop key skills and appreciate how science impacts on society. To enable this to happen, and to be achievable within the 180-hour time frame, the learning outcomes will have to be limited in number, but rich in content. This is an area where the consultation process failed to reach consensus. Although there were repeated calls for reduction in content in all three syllabuses, teachers find it difficult to imagine a syllabus that does not retain all of the traditional areas of learning. There is also new content to be added. Technology has had a phenomenal impact on our understanding of science; developments at the Nano scale, genome mapping, space exploration, the Large Hadron Collider and the impact of humanity on Earth's ecological balance all deserve their place in a 21st century science syllabus.

One of the main areas of feedback emerging from the consultation was a strong desire for a change in assessment. There was consensus that the assessment of the revised syllabuses should not reward rote learning; assessment that meets the objectives of the revised syllabuses will include higher order thinking and problem solving. It will not be predictable, rather it will require learners to deal with unseen and unfamiliar concepts by applying prior learning.

Appendix

Appendix 1: List of submissions

Carmel De Grae , Physics teacher
Dr. Creidhe O'Sullivan, Physics lecturer NUI Maynooth
Dan O'Regan Physics teacher
Department of Chemistry NUI Maynooth
Discover Science and Engineering (Managed by Forfás)
Engineers Ireland
Ger Sharpe , Chemistry teacher
Institute of Physics
Irish Business and Employers Confederation and Pharmachemical Ireland
Irish Science Teachers Association
Dr. John Hennessy Physics teacher
Microbiology Department, University College Cork
National Centre for Excellence in Mathematics and Science Teaching and Learning
National Centre for Excellence in Mathematics and Science Teaching and Learning
National University of Ireland, Chemistry Departments
Dr. Niall Smith and Frances Mc Carthy on behalf of the Blackrock Castle Observatory team
Dr. Padraig Murphy- Programme director, MSc in Science Communication, DCU
Paul Whelan - www.biology.ie
Professor Peter Mitchell MRIA Professor Emeritus, UCD School of Physics and member of the RIA's Science Education Committee
Professor Patrick Fitzpatrick, Head of the College of Science, Engineering and Food Science, UCC
Professor Richard O'Kennedy, Prof. of Biological Sciences and VP for Learning Innovation,DCU, Member of the Life Sciences Committee, RIA
Dr. Ronan McNulty, Senior lecturer in physics, UCD. Research scientist at CERN
Royal Society of Chemistry Education Division Ireland
School of Physics UCD
Sonya Coffey - Coordinator of Teaching Practice in St. Angela's College, Sligo
Teachers' Union of Ireland and Association of Secondary School Teachers
The Health and Safety Authority
Undergraduate Science Education Students, NUI Maynooth

These submissions will be published on the NCCA website at www.ncca.ie

Appendix II: Online Questionnaire

1. Introduction

As part of its ongoing review of senior cycle, the National Council for Curriculum and Assessment (NCCA) has been involved in a process of revising existing subjects and developing a number of new subjects and short courses. Draft syllabuses in biology physics and chemistry are now the subject of a consultation process.

Now that you have read the syllabus and looked at the consultation material which can be found at **www.ncca.ie**, we would like to hear your views.

2. Responder information

*1. I am responding as a

- ◯ Teacher
- ◯ School Principal/ Deputy Principal
- ◯ Second level student
- ◯ Parent/Guardian
- ◯ Other

(please specify)

2. School type (if applicable)

- ◯ Voluntary secondary school
- ◯ Community school
- ◯ Comprehensive school
- ◯ Vocational school
- ◯ Community college
- ◯ Other

(please specify)

3. Syllabus layout, design and readability

3. Please indicate your level of agreement with each of the following statements:

	Strongly agree	Agree	Agree somewhat	Disagree	Strongly disagree
The layout of the syllabus is clear.	◯	◯	◯	◯	◯
The language is easy to understand.	◯	◯	◯	◯	◯
The introduction, aims and objectives give me an accurate understanding of what the syllabus sets out to achieve.	◯	◯	◯	◯	◯
The overview of the syllabus provides a useful summary of what will be studied in this course.	◯	◯	◯	◯	◯
The five units of study provide a clear structure.	◯	◯	◯	◯	◯
The sections and learning outcomes are clear and unambiguous.	◯	◯	◯	◯	◯
The assessment section provides me with a good understanding of the assessment demands of this subject.	◯	◯	◯	◯	◯

Any additional comments

4. Content and learning outcomes

A distinctive feature of the revised syllabus is the inclusion of learning outcomes. Learning outcomes describe what students should be able to know and do as a result of studying the subject.

4. Please indicate your level of agreement with each of the following statements:

	Strongly agree	Agree	Agree somewhat	Disagree	Strongly disagree
The learning outcomes describe clearly what students should be able to know and do as a result of studying the course.	◯	◯	◯	◯	◯
The learning outcomes will be useful in planning and designing teaching and learning in the course.	◯	◯	◯	◯	◯
The learning outcomes will provide a strong basis for the assessment of achievement in the course.	◯	◯	◯	◯	◯
The learning outcomes will provide a support for teaching and learning in mixed-ability settings.	◯	◯	◯	◯	◯

You may wish to make further comments on learning outcomes. If so, please use the space below.

5. Syllabus structure and content

The following question invites your specific comments on the units of study in the (chemistry, biology, physics) syllabus.

5. Please express your opinion on the units in the (chemistry, biology, physics) syllabus, in the box below

6. Do you feel there are further areas of the syllabus that should be revised/removed/reduced.

- ◯ Yes
- ◯ No

Please specify topic and suggest change/s in the space provided.

7. Are there any topics in the syllabus which need further explanation/clarification?

- ◯ Yes
- ◯ No

Please give details of the topic and outline your area of concern in the space provided.

8. Are there any learning outcomes which you think are inappropriately assigned as Higher level or Ordinary level?

- ◯ Yes
- ◯ No

If so, please give details of the topic, learning outcome and area of concern in the space provided.

6. Assessment

9. Do you think that the assessment arrangements in the draft (chemistry, biology, physics) syllabus will be effective in examining students' learning in this subject?

- ◯ Yes
- ◯ No

Please give details in the space provided.

10. Do you think that the proposed second component of assessment will assess the process skills that cannot be adequately assessed in the written paper?

- ◯ Yes
- ◯ No

Please give details in the space provided.

7. Some concluding questions

Leaving Certificate (chemistry, biology, physics) aims to stimulate and sustain learners' interest in and enjoyment of (chemistry, biology, physics) while developing an understanding of the fundamental principles of(chemistry, biology, physics).

11. Please indicate your level of agreement with the following statements. The revised Leaving Certificate (chemistry, biology, physics) syllabus will:

	strongly agree	Agree	Agree somewhat	Disagree	Strongly disagree
Develop the skills learners need to apply their knowledge and understanding of (chemistry, biology, physics) to familiar and unfamiliar situations	◯	◯	◯	◯	◯
Allow for a wide variety of teaching and learning approaches that will enabling learners to make connections between (chemistry, biology, physics)and other subjects, and with everyday experiences	◯	◯	◯	◯	◯
Develop in learners, skills in scientific inquiry including the ability to interpret and analyse qualitative and quantitative data	◯	◯	◯	◯	◯
Provide opportunities for learners to assess the validity, reliability and credibility of scientific information	◯	◯	◯	◯	◯
Provide learners with skills to explain, evaluate and communicate the results of their experimental and investigative activities in a variety of formats	◯	◯	◯	◯	◯
Develop an understanding of the ethical, historical, environmental, and technological aspects of (chemistry, biology, physics)	◯	◯	◯	◯	◯
Develop learners interest and enthusiasm for (chemistry, biology, physics), including developing an interest in further study and careers in the subject	◯	◯	◯	◯	◯

12. Do you have any further comments you would like to make regarding the draft (chemistry, biology, physics) syllabus?

Thank you

Thank you for taking the time to complete this questionnaire. If you have completed a hard copy of this questionnaire, please return it to:

Senior Cycle Consultation (Science),
NCCA,
24 Merrion Square,
Dublin 2.

A summary of the findings will be published on the NCCA website at the end of the consultation. If you have an interest in other areas for consultation, please revisit the consultation page at www.ncca.ie/consultations

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